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Doctoral Defense Announcement

Abstract

Development of Patient-specific In-silico and In-vitro Modeling Framework to Investigate and Mitigate Post-Transcatheter Aortic Valve Replacement Complications in Bicuspid Aortic Valve Patients

By

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Bicuspid aortic valve (BAV) is the most common congenital heart defect. Morphological heterogeneity and restrictive nature of the valves give rise to abnormal hemodynamics which expedite the development of leaflet calcification and aortic stenosis in BAV patients. Transcatheter aortic valve replacement (TAVR) is a minimally-invasive procedure which offers an alternative to standard surgical aortic valve replacement procedure. Initially developed to treat high surgical risk patients with severe aortic stenosis, TAVR has recently been approved for intermediate and low-risk patient populations which includes young, BAV patients. While this is likely to increase the number of BAV patient candidates for TAVR procedure, it also raises concerns among the surgical communities since BAV is considered as challenging anatomy for TAVR procedure. Numerous studies have demonstrated that heavy and asymmetric leaflet calcification and structural complexities of the BAV patients will often exacerbate post-TAVR complications. Patient-specific computational and in-vitro modeling techniques of TAVR procedure are gaining traction for assessing various post-TAVR complications. However, studies focused on TAVR modeling in BAV are scant. In the USA, BAV patients have been excluded from all the major clinical trials that led to TAVR commercialization, which is why the outcomes and performance of those TAVR devices cannot be generalized towards BAV populations. All these reasons warrant detailed and individualized attention toward BAV patients before considering them for TAVR procedure, which could be provided by using patient-specific modeling techniques. The aims of this thesis are to develop in-vitro and in-silico patient-specific TAVR modeling frameworks for analyzing post-TAVR complications in BAV patients, and investigate calcified aortic valve material properties in an effort to optimize these frameworks. The conclusions from these aims will provide the clinicians with valuable information that is necessary to analyze the feasibility of the TAVR procedure, select the optimal device, predict various structural and hemodynamic outcomes in each patient prior to the procedure, and promote the practice of engineering driven medicine in order to achieve better clinical outcomes for the understudied BAV patient population.

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